

# A statistical analysis of a Galactic all sky survey at 1.4 GHz

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**Abstract.** Radio surveys at frequencies of  $\sim 1$  GHz allow to map the synchrotron emission (SE) in a frequency range where (except for very low Galactic latitudes or towards localized regions) it dominates over the other radio components. New all sky total intensity and polarization data at 1.4 GHz have been recently collected. We focus on the Galactic radio emission correlation properties described in terms of angular power spectrum (APS). We present for the first time the APS, in both total intensity and polarization modes, for some representative Galactic cuts and suitable APS power law (PL) parametrizations.

**Key words:** Galaxy: general – polarization – magnetic fields – cosmic microwave background

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## 1. Introduction

In the recent years a complete coverage of the radio sky at 1420 MHz, both in total intensity and in polarization intensity, has been achieved. It derives from the combination of total intensity surveys (Reich 1982, Reich & Reich 1986, Reich et al. 2001) and of the DRAO (Wolleben et al. 2004) and the Villa Elisa (Testori et al. 2004) polarization surveys, covering respectively the Northern and Southern celestial hemisphere, sensitive to the Stokes parameters  $Q$  and  $U$ . All these surveys have a FWHM resolution of  $36'$ . The sky has been sampled at steps of  $\simeq 15'$  in the total intensity and Villa Elisa surveys. The preliminary version of the DRAO survey used in this work has a sky sampling much better than that of the Leiden surveys (Brouw & Spoelstra 1976). The typical sensitivities of these surveys are of few tens of mK. These properties allow a reliable study of the Galactic correlation properties up to a multipole  $\ell_{max} \sim 250$  ( $\ell_{max} \sim 180/\vartheta_{min}(^{\circ})$ , where  $\vartheta_{min}$  is the smallest angular scale at which accurate information can be extracted).

## 2. Results

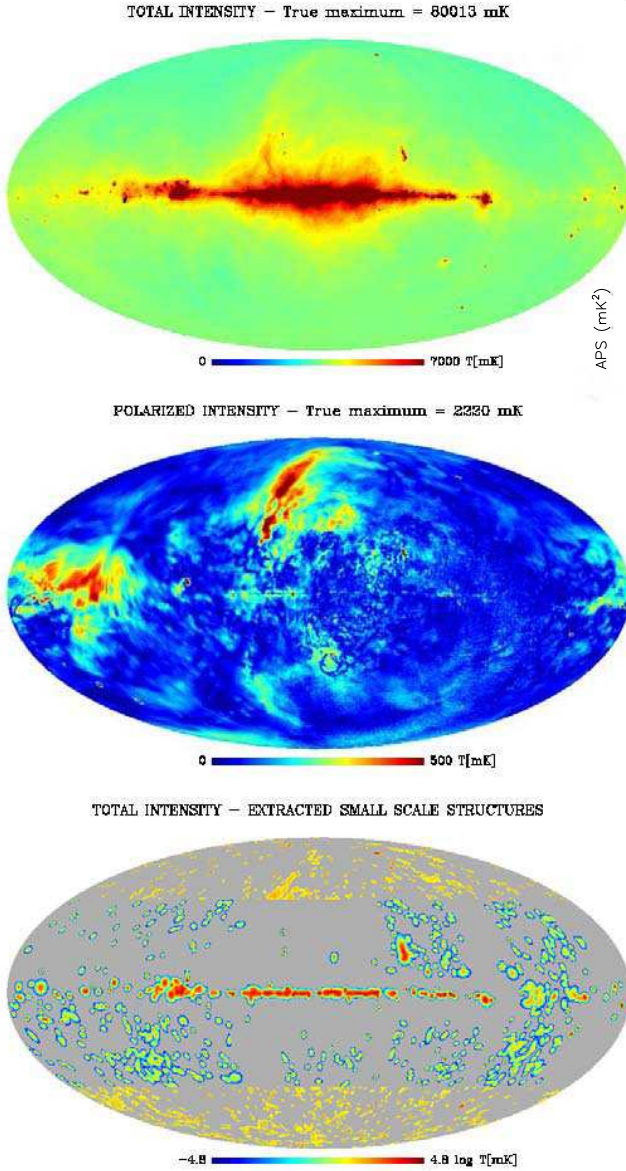
We have properly projected (La Porta et al. 2005) these surveys from their original equidistant cylindrical pixelization into the HEALPix scheme (Górski et al. 2005) and computed their APS with the ANAFast facility.

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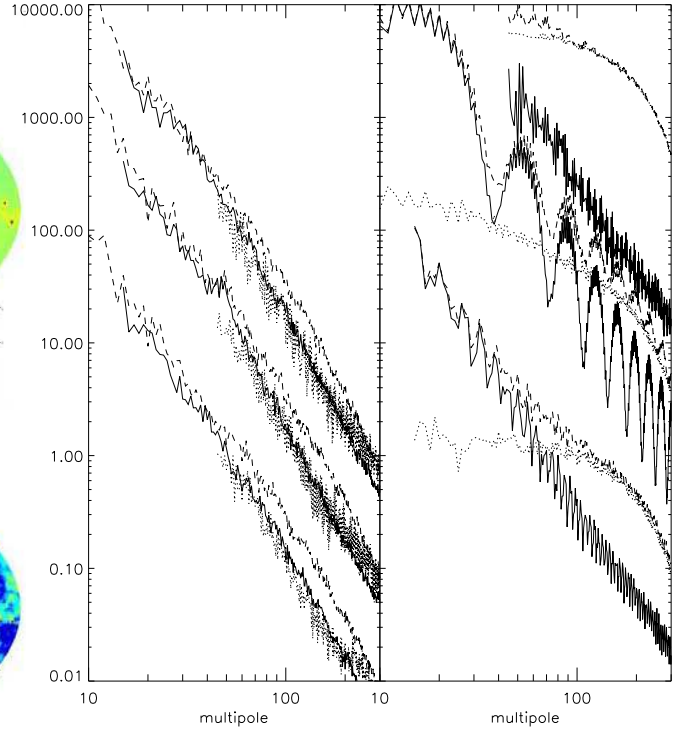
Fig. 1 shows the maps derived from our projection. As evident, the radio sky appears very different in total intensity ( $T$ ) and polarization ( $PI$ ): the polarized intensity on the Galactic plane is relatively less bright than in total intensity and exhibits important structures at high Galactic latitudes. We then expect a dependence of the APS amplitude on the Galactic latitude,  $b$ , stronger in total intensity than in polarization.

From the HEALPix maps of total and polarized intensity and of  $Q$  and  $U$  parameters we have computed the APS, namely the  $T$ ,  $PI$ ,  $E$ , and  $B$  modes, by applying various Galactic cuts. In particular, we exclude in the present analysis the region at  $|b| < 5^{\circ}$  where the Galactic free-free emission cannot be neglected to focus on the SE correlation properties. Fig. 2 shows some representative results. As evident, all the polarization modes, and in particular the  $E$  and  $B$  modes, are very similar and exhibit PL shapes (left panel). Their typical slopes are in the range  $\simeq [-2.5, -3]$ , in good agreement with the results found by La Porta & Burigana (2005) in the analysis of the Leiden surveys at 1411 MHz. By varying the Galactic cut, the APS amplitudes change by a factor  $\sim 3$ . At  $\ell \simeq 100$  they are in the range  $\sim [0.07, 0.2]$  mK<sup>2</sup>. The  $T$  mode (right panel) is in general not well approximated by a single PL but tends to flatten at  $\ell \sim 100$  (while the power decreasing at  $\ell \gtrsim 200$  is the obvious effect of beam smoothing), particularly at high  $|b|$ . To better understand this aspect we performed a dedicated subtraction of the discrete structures (DSs) in the total intensity map. The different level of the diffuse Galactic emission at low and high  $|b|$  implies a  $|b|$  dependent source detection level. We are confident to have



**Fig. 1.** All sky maps of the total and polarized intensity at 1420 MHz (brightness temperature) reprojected according to the HEALPix scheme (pixel size  $\simeq 6.9'$ ) and of the discrete small scale structures (mainly extragalactic point-like sources at high Galactic latitudes and Galactic point-like or relatively extended sources at low Galactic latitudes) extracted from the total intensity map (see text).

identified DSs (see Fig. 1) with fluxes above  $\simeq 1$  Jy (resp.  $\simeq 5$  Jy) at  $|b| \gtrsim 45^\circ$  (resp. at  $|b| \lesssim 45^\circ$ ). We computed the  $T$  APS of the map *i*) including only the detected DSs and *ii*) of the diffuse component (plus, obviously, the undetected sources) derived subtracting DSs from the original total intensity map. DSs explain the flattening found at  $\ell \sim 100$  for Galactic cuts  $|b| \geq 5^\circ$  and  $|b| \geq 30^\circ$  while at high Galactic latitudes ( $|b| \geq 70^\circ$ ) they provide the major contribution to the APS also at  $40 \lesssim \ell \lesssim 100$ . At  $\ell \lesssim 100$  (where beam smoothing is negligible) the APS of detected DSs is nearly flat for  $|b| \geq 30^\circ$  and  $70^\circ$ , as expected in the case of a bulk contribution from extragalactic radiosources. On the contrary, including also the region at  $5^\circ \leq |b| \leq 30^\circ$  the APS of DSs decreases with  $\ell$ , as expected since the large scale cor-



**Fig. 2.** *Left panel:* APS derived from the  $PI$  map and from the corresponding  $Q$  and  $U$  maps. The lines starting from  $\ell = 10$  (dashes), 15 (solid lines), and 45 (dots) refer to  $|b| \geq 5^\circ$ ,  $30^\circ$ , and  $70^\circ$ , respectively. From the bottom to the top, each set of three lines refers to the  $PI$  APS, the  $E$  mode (multiplied by 10), and the  $B$  mode (multiplied by 100). *Right panel:* APS derived from the  $T$  map for  $|b| \geq 5^\circ$  (lines starting from  $\ell = 10$ , APS multiplied by 10),  $30^\circ$  (lines starting from  $\ell = 15$ ), and  $70^\circ$  (lines starting from  $\ell = 45$ , APS multiplied by  $10^3$ ). We consider the original map (dashes), the map of the extracted DSs (dots), the diffuse component (solid lines).

relation of the Galactic discrete sources. Finally, the APSs found for the diffuse component are again well described by PLs, with typical slopes in the range  $\simeq [-2.5, -3]$ . As expected, the APS amplitude strongly depends on the applied Galactic cuts, being not very different for  $|b| \geq 30^\circ$  or  $70^\circ$  ( $\approx$  some  $\times 10^{-1}$   $\text{mK}^2$  at  $\ell \simeq 100$ ) but significantly larger ( $\approx$  some  $\text{mK}^2$  at  $\ell \simeq 100$ ) for  $|b| \geq 5^\circ$ .

The accurate modelling of the Galactic diffuse SE in both total intensity and polarization, necessary to properly map the intrinsic cosmic microwave background anisotropies, provides relevant information on the Galactic magnetic field structure and the cosmic ray electron density distribution.

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